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(54) Title: DATA TRANSMISSION METHOD AND APPARATUS

(57) Abstract

A method of increasing the data transmission capacity of a cable type communication system comprises providing spread sprectum (pseudo-noise) apparatus connected or coupled to the cable for simultaneous communication therethrough with the existing communication equipment without interference with the latter. There is also disclosed a local area network computer system employing radiated spread spectrum signals using a common code sequence.

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DATA TRANSMISSION METHOD AND APPARATUS

This invention relates to a method of data transmission and apparatus therefor. The invention particularly, but not exclusively, relates to the transmission of data through cables such as existing cable TV systems, and to the transmission of data between two or more computers forming, for example, part of a local area computer network. The invention may also be applied to related data transmission systems.

As regards transmission of data via cables, whether such cables are of the conventional electrically conducting coaxial kind or of the more recent fibre optic kind, there is a well known and well defined limit to the transmission capacity of such a cable. The capacity of such a cable, using conventional data transmission techniques depends on the band width employed for the signals transmitted. This in turn depends on whether amplitude or frequency or phase modulation is employed.

In the case of Community Antenna TV Systems (CATV) the cable is often capable of transmitting up to 35 channels of TV signals. However, even this level of use tends to lead to a significant noise level in the cable and to a degree of cross-modulation. As a result, cables of this sort are usually under utilized, and one object of the present invention is to provide means whereby this situation can be, at least to some extent alleviated, and/

or to provide means whereby the data transmission capacity of a cable can be increased.

According to this aspect of the present invention there is provided a method of increasing the data transmission capacity of a cable type communication system as defined in the accompanying claims.

In this specification and the claims thereof , by the expression " conventional data transmission apparatus and methods " , and like expressions , it is intended to refer to data transmission apparatus presently in use at the date of this application , or similar well known such apparatus , this apparatus typically generating narrow bandwidth signals (i.e. signals occupying bandwiths of the same order as the information stream to be transmitted) of the amplitude or frequency or phase modulated kind , the data transmission apparatus being constructed to send and receive at defined and spaced frequencies , signals modulated in this manner.

By the expression " data " as used in this specification and claims there is meant not only signals having encoded therein information readable by suitable apparatus such as a computer , but also voice and other signals and the like which may be

transmitted for the purpose of a telephone system or other communication system.

By the expression " spread spectrum " as applied to communication apparatus , for example transmission and/or receiving apparatus , and otherwise in this application , there is meant the use of a radio frequency electro-magnetic wave modulated in any of three ways :

1] Modulation of the carrier by a digital code sequence of which the bit rate is much higher than the information signal bandwidth . Such a system may be called a " direct sequence " modulated system. A direct sequence modulation system typically occupies more than ten times the bandwidth of the originating signal.

2] Carrier frequency shifting in discrete increments in a pattern dictated by a code sequence. Such a system may be referred to as a " frequency hopper ". A frequency hopper system typically occupies more than ten times the bandwidth of the originating signal . The transmitter jumps from frequency to frequency within some predetermined frequency set , the order of frequency usage being determined by a code sequence.

3] Pulsed-FM (frequency modulation) or

" chirp " modulation in which a carrier is swept over a wide band during a given pulse interval.

The invention also provides apparatus for performing the method of increasing the data transmission capacity of a cable type communication system as defined in the accompanying claims.

The data transmitted may originate from any suitable source such as a computer or other apparatus such as facsimile transmission apparatus capable of generating digital signals or the like.

In an embodiment described below , a cable-connected computer network is provided in which spread spectrum data transmission signals are employed which are readable and transmittable only by use of suitably matched pairs of modulator/demodulator apparatus (modems) , whereby considerable security of information is provided .

Another embodiment of this aspect of the invention provides for CATV cables to be used for providing a telephone network carrying multiple voice channels in addition to the existing cable TV use of the network and without any significant interference with the latter .

Another aspect of the invention relates to data transmission by means of radiated signals as opposed to signals transmitted by cable or the like.

This aspect of the invention relates particularly, but not exclusively , to the provision of radiated signals linking computer terminals .

Presently available methods of data transmission more or less rule out the use of radiated transmission signals for the interconnection of computer terminals , except for low data rates . There is considerable demand for such a system but , for example , conventional radio techniques cannot be used due to bandwidth and licensing restrictions on high data rates . This therefore represents an area of technology in which existing communication techniques have been unable to meet a well defined technical requirement.

According to this aspect of the invention there is provided a method of communicating between a series of computers or computer terminals so as to form a local area computer network , as defined in the accompanying claims.

In an embodiment described below there is provided a method of linking two sets of data handling apparatus , such as computers , by means of radiated signals . The method comprises generating a radio frequency carrier wave , modulating the carrier wave to produce a spread spectrum wave , and using the spread spectrum wave to carry signals between said sets of apparatus.

This aspect of the invention also provides apparatus for performing the method of the invention. Such apparatus may comprise a modulator/ demodulator unit associated with each set of data handling apparatus , the modem units being set to corresponding codes .

The invention also provides a method and apparatus comprising any novel step or feature disclosed herein or any novel combination of such steps or features.

Embodiments of the invention will now be described by way of example with reference to the accompanying drawings in which :

Fig. 1 shows a block diagram of a direct sequence spread spectrum (or pseudo-noise - PN) transmitter ;

Fig. 2 shows a spread spectrum or PN receiver in block diagram form ;

Fig. 3 shows a modification , in block diagram form , of the transmitter of Fig. 1 ;

Fig. 4 shows a radiated (broadcast) data transmission system , using a cable to link transponder units ;

Fig. 5 shows , again in block diagram form , a cable system , using a headend unit to bridge forward and reverse channels ; and

Fig. 6 shows a block diagram of a fibre-optic local area network .

Fig.s 1 and 3 show two alternative forms of spread spectrum or direct sequence transmitter . In the apparatus 10 of Fig. 1 , information signals from the data source 12 are transformed into digital form by the data encoder 14 and employed by a digital modulator 16 for incorporation in the spread spectrum signal produced by a pseudo-noise (PN) generator 18 by adding the digital information to the spectrum-spreading code produced by the PN generator before such code is used for modulating the carrier produced by carrier generator 20 .

Modulation of the carrier is effected in the transmitter proper 22 from which the output signal passes via power amplifier (PA) 24 to output connector 26 .

This technique is applicable to any spread spectrum apparatus that uses a code sequence to determine its radio frequency bandwidth , such as direct sequence systems or frequency hopping systems. The information to be sent must be in a digital form for the purpose of addition to the code sequence .

In the embodiment of Fig. 3 the data from data source 30 is transformed into digital form by data encoder 32 and in that form is employed in a carrier

modulator 34 to modulate the carrier produced by carrier generator 36 before the carrier is encoded or spread by the pseudo-noise signal from PN generator 38 in the transmitter proper 40 , after which the output signal passes via power amplifier 42 to output connector 44 and so to the transmission medium.

Modulation of the carrier before spreading is effected by a suitable form of angle modulation so as to generate a constant-power radio frequency envelope.

In both Figs. 1 and 3 , the data encoders 14 and 32 put the data from the data sources 12 and 30 into suitable digital form . In Fig. 1 , the output from the data encoder 14 is employed by the digital modulator 16 for insertion into the spectrum-spreading code produced by the spread spectrum or pseudo-noise (PN) generator 18 . The data-containing pseudo-noise signal is added to the carrier from the carrier generator 20 in the transmitter proper 22 from which the output signal is passed via the power amplifier 24 to the cable system or an antenna , as described below.

In the Fig. 3 embodiment , the carrier itself is modulated by the data from the data encoder 32 prior to modulation in the transmitter proper 40 by the

pseudo-noise from the PN generator 38.

In the case both of the apparatus of Fig.1 and that of Fig. 3 , the spread spectrum signal obtained by modulating the carrier with a pseudo-random sequence is a double sideband-suppressed carrier signal occupying a large frequency band , compared with the original modulation bandwidth of the data source.

Fig. 2 shows a spread spectrum or PN receiver 50 in which an input conductor 52 feeds the received signal to a preamplifier 54 from which the amplified signal is processed in primary and secondary circuits 56 , 58 and 60 , 62 with regard to the PN code acquisition and code locking , and the carrier signal acquisition / tracking and locking . A locally generated code sequence is compared with the received signal. When a " fit " occurs , recovery of the carrier takes place. Demodulation of the carrier in circuit 64 and recovery of the data stream by way of output circuit 66 can then occur. Extensive use of phase lock techniques is made to ensure tracking of the incoming signal. Synchronisation and locking circuits 68 and 70 are provided as shown.

In simplified systems , the synchronisation clock information may be transmitted separately thus easing the problems of maintaining synchronism.

Turning now to the application of the transmitter and receiver apparatus of Figs. 1 to 3 , to cable-type data transmission systems , it is to be noted that on a coaxial cable distribution system , a limited amount of bandwidth is available to carry TV signals from the headend to users. When the cable becomes fully occupied , further channels cannot be added by use of existing techniques.

However , the spread spectrum or pseudo-noise (PN) signals produced by the apparatus of Figs. 1 and 3 can co-exist in the same frequency band as existing services on cable transmission systems without significant mutual interference.

Such existing or conventional data transmission systems employ narrow band modulation systems of the amplitude or frequency or phase modulation kind having high and localised spectral power transmission. These systems do not interfere with the wideband low energy content signal of the spread spectrum apparatus disclosed above, whereby additional signal transmission channels are readily provided in existing cable TV networks , regardless of frequency allocation and cable channel operating frequencies. Furthermore , the nature of the spread spectrum transmission gives a high level of security ,

thereby preventing unauthorised access to the data. Such access is only available with suitable apparatus programmed to recognise the coding sequence. Such security is important in relation not only to pay-as-you-use services , but also for data security.

A spread spectrum PN data network employing transmission and reception apparatus as indicated in Figs. 1 to 3 may be installed on an existing cable network without modification to the installed and existing cable and signal transmission and reception and amplification hardware . The new users of the system will each employ a modem unit set to a unique selected code , to allow reception and transmission of PN signals. The spread spectrum apparatus is merely connected to the cable directly and the system functions with these additional channels just as if the channel capacity of the cable had been increased - which in reality it has.

In a fully flexible system , code distribution may occur either from a central " key distribution " unit , or as a pre-loaded programme in the modem unit. Thus , to establish a data link with a second user , the two units are set to the same code sequence, and synchronism is achieved . Any number of units may be simultaneously in synchronism , permitting " broadcast " transmissions . Access to the transmission

medium may be governed by any one of the established data network protocols , for example CSMA - CD , token passing etc..

Other services such as alarms , audio circuits etc. may be added to " full " systems using this technique , as well as pure data.

Figs. 4 and 5 indicate further applications of the spread spectrum technique. In Fig. 4 , a radiated or broadcast system employs a trunk cable 80 having transponder units 82 , 84 connected thereto at convenient local intervals. The transponder units are ceiling mounted and individual data transmission units 86 , 88 , 90 and 92 , 94 (such as suitably equipped micro-computers) transmit data thereto and hence to the trunk cable , and vice versa , by means of spread spectrum radiated signals 96 of the kind discussed above. In this way , a series of data sources can be conveniently connected to a central main computer , for example , in a very effective way.

In the embodiment of Fig. 5 , a cable system 100 comprises a cable 102 having spaced taps 104 , 106 , 108 for local inputs directly connected thereby from local users with apparatus 110 , 112 , for example as described in the preceding embodiments.

A headend unit 114 is provided to bridge the forward and reverse channels of this pure cable connection system .

Fig. 6 shows a fibre-optic based local area network (LAN) structure comprising a fibre-optic cable 120 connected to a spread spectrum modem 121 of the kind discussed above and provided with optical taps 122 , 124 providing local connections for additional modems 126 . These optical taps are analogous to those used on broadband networks , and provide a sample of the complete optical spectrum present on the cable to each user . An optical splitter 128 serves to connect spread spectrum modems 130 to cable 120 .

The transmitter and receiver techniques of the embodiment of Fig. 6 are very much on the lines of those of Figs. 1 , 2 and 3 but use light-emitting diodes/lasers to transmit , and photodiodes or similar to receive the optical signal.

This technique avoids the requirement to use " wave-division " multiplexing to separate services on the same fibre and thus avoids the consequential complex technology to implement this.

The figure shows a code division multiplex arrangement , with optical splitters allowing the insertion of a number of signals into the fibre.

Among the advantages of the above-described embodiments employing radiated transmission of spread spectrum signals are the following :

1. Solves the frequency allocation problem.

2. Does not interfere with conventional radio communications.

3. Very high interference rejection .

4. Selective addressing capability.

5. Data screened from eavesdroppers - inherent security in the system coding.

6. Elimination of cabling from desk-mounted visual display unit or similar , back to the computers.

Likewise , the advantages of the above-described cable system embodiments include the following :

1. Solves the problem of frequency allocation on " full " cable systems.

2. Very high interference rejection.

3. Selective addressing capability.

4. Code division multiplexing available for multiple access.

5. Data screened from eavesdroppers on public cable systems.

Thus , the embodiments enable existing cable systems of data transmission to have their capacity increased without interfering with existing equipment or users. This enables additional TV channels to be

transmitted or other data services , including telephone channels , computer links, etc.. As regards data transmission by the radiated spread spectrum technique , the embodiment provides a means for radio links between computers in a manner allowing transmission of data at rates hitherto contrary to the regulations , whereby non cable-linked computer networks become attractive and feasible.

Many modifications can be made within the embodiments described above while remaining within the scope of the invention . The structure and arrangement of the hardware employed for embodying the invention is a matter of routine detailed design and will be made the subject of further patent applications.

In the application of the above embodiments to local computer networks , in its simplest form , it is envisaged that computer users would each equip their computer apparatus with spread spectrum transmission / reception apparatus of the kind described in Figs. 1 to 3 above and by use of an appropriate modem , suitably coded , users would be able to receive and transmit the appropriate coded signals for connecting up to the local computer network , just as if each one had a direct cable link.

In this specification and the claims , references to the transmission capacity of a cable and the like are to be interpreted having regard to the following. It is to be understood that transmission capacity is limited by the Shannon bandwidth / information content constraints . The embodiments of the invention enable the limits defined by these constraints to be more nearly approached on practical systems where noise and distortion factors must be taken account of. Accordingly , references in this specification to increasing the data transmission capacity of a cable type communication system , for example , are to be interpreted accordingly as referring to increasing the practical limits of data transmission capacity .

CLAIMS :

1. A method of increasing the data transmission capacity of a cable type communication system comprising providing a transmission cable and providing also primary communication apparatus connected or coupled thereto , said primary communication apparatus employing amplitude or frequency or phase modulation , characterised by the step of providing secondary communication apparatus (10 , 50) and the step of connecting or coupling said secondary communication apparatus to said cable (100) said secondary communication apparatus comprising spread spectrum communication apparatus (as defined herein) , and the method further comprising the step of simultaneously transmitting data through said cable by means both of said primary and said secondary communication apparatus.

2. A method according to claim 1 characterised in that said primary communication apparatus and said cable form a Community Antenna TV system , the method comprising the step of transmitting a plurality of TV channels through said cable while simultaneously transmitting a plurality of streams of data through said cable by means of a corresponding

plurality of sets of said spread spectrum communication apparatus employing one or more code sequences.

3. A method according to claim 2 characterised by the step of employing a common code sequence for said sets of spread spectrum communication apparatus and using said apparatus to communicate between a series of computers , thereby forming a local computer network .

4. A method according to claim 2 characterised by the step of employing a series of different code sequences for said sets of spread spectrum communication apparatus and using said apparatus to communicate between a series of telephones , thereby forming a local telephone network.

5. A method according to any one of the preceding claims characterised in that said secondary communication apparatus is coupled to the cable through local radiation transmission and radiation receiving apparatus (82 , 84 and 86 , 88 , 90 , 92 and 94) adapted respectively to radiate and receive in spread spectrum encoded form signals (96) from said secondary communication apparatus.

6. A method of communicating between a series of computers or computer terminals so as to form a local area computer network , the method comprising providing communication apparatus for each computer or terminal

whereby computer data can be transmitted and received between said computers or terminals , characterised in that said communication apparatus comprises radiation transmission and receiving apparatus adapted respectively to radiate and receive in spread spectrum encoded form , signals from said computers or terminals , the method comprising the step of employing the same coded sequence for a series of said computers or terminals whereby these latter can freely communicate with each other .

7. Apparatus for performing a method according to any one of the preceding claims characterised by said spread spectrum communication apparatus comprising a data encoder adapted to transform into digital form the information signal fed thereto.

8. Apparatus according to claim 7 characterised in that the output from the data encoder (14) is fed to a digital modulator (16) for insertion into the spectrum spreading code produced by a pseudo-noise generator (18) prior to modulation of a carrier signal from a carrier generator (20).

9. Apparatus according to claim 7 characterised in that the output from the data encoder (32) is employed to modulate the carrier signal from the carrier generator (36) prior to modulation of the

latter by the spectrum spreading code of a pseudo-noise generator (38).

10. Apparatus according to any one of claims 7 to 9 characterised in that the spread spectrum communication apparatus (10) is adapted to produce a double sideband-suppressed carrier signal.

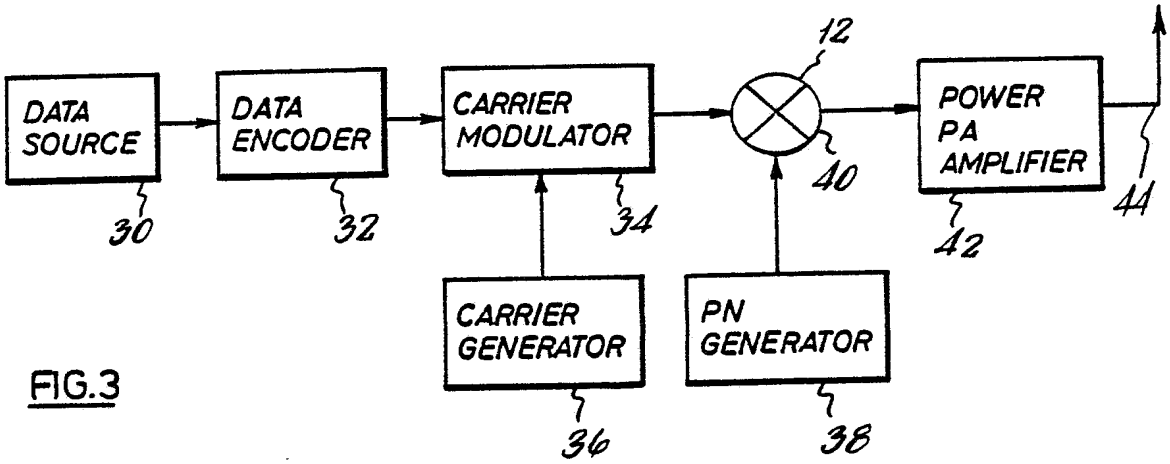
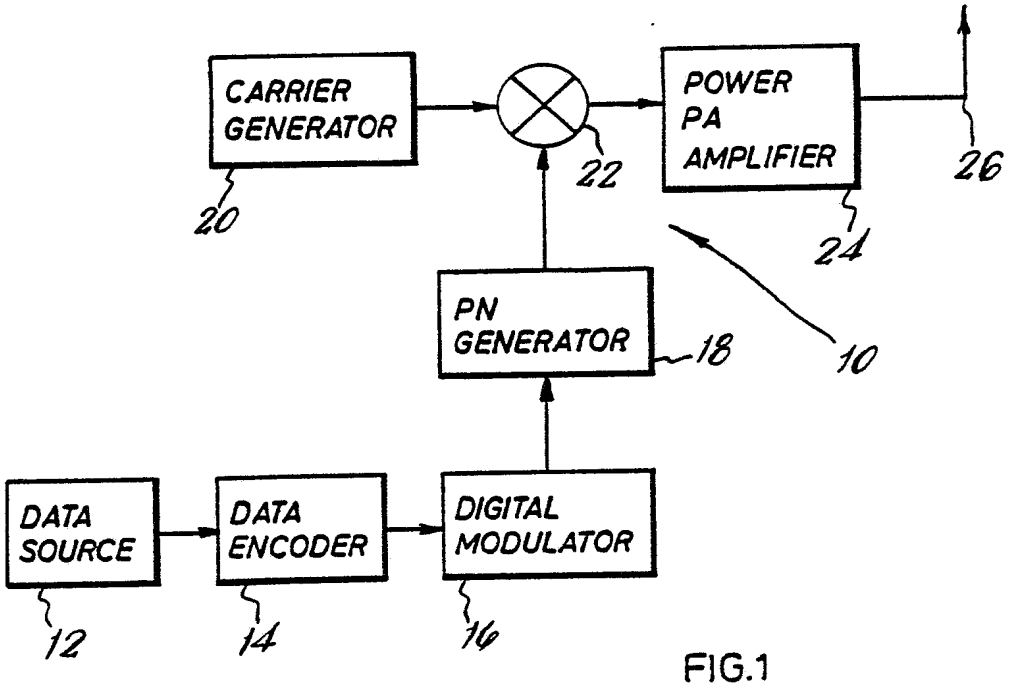

DATA SOURCE
30
DATA ENCODER
32
CARRIER MODULATOR
34
12
40
POWER PA AMPLIFIER
42
44
CARRIER GENERATOR
36
PN GENERATOR
38

FIG.3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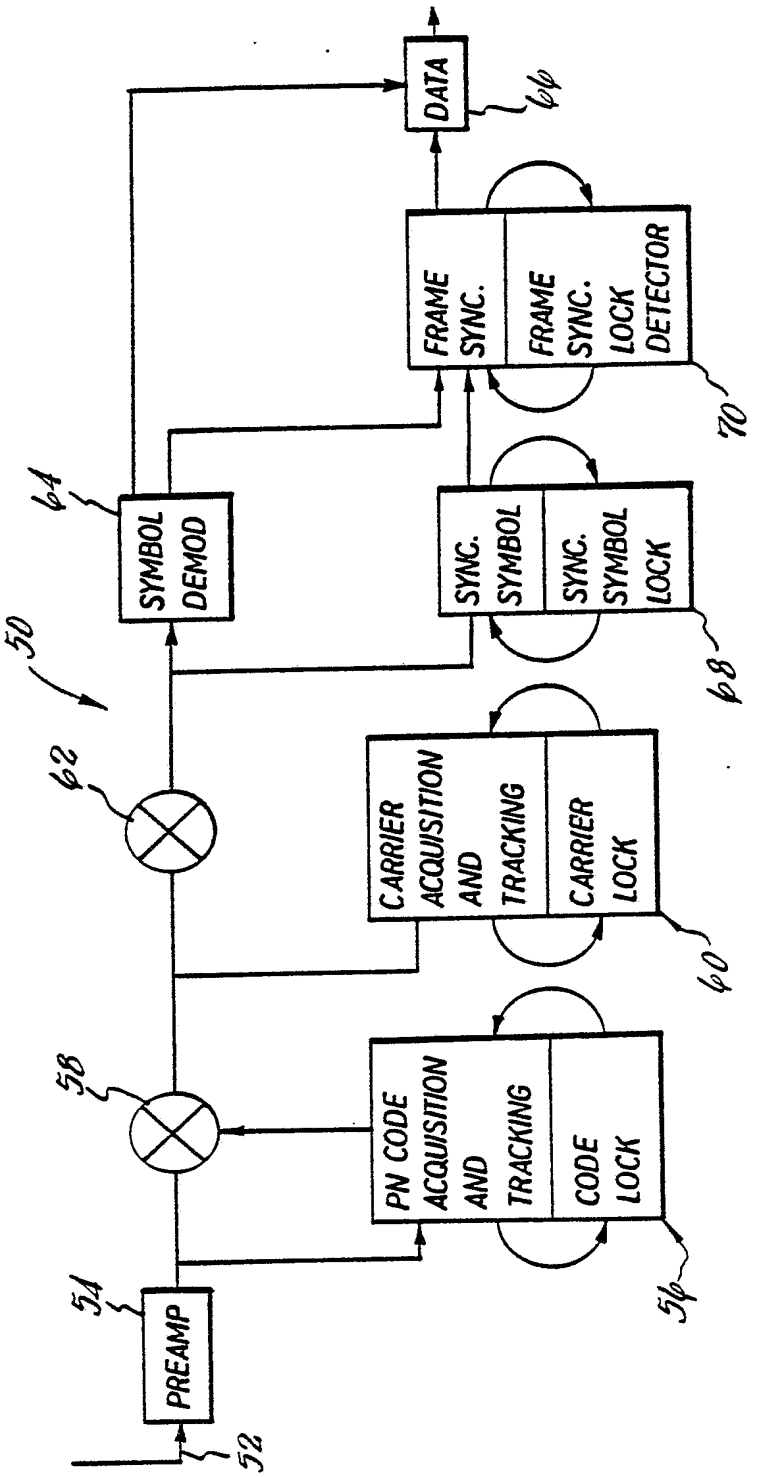
20
22
POWER PA AMPLIFIER
24
26
PN GENERATOR
18
10
DATA SOURCE
12
DATA ENCODER
14
DIGITAL MODULATOR
16

FIG.1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FRAME SYNC. LOCK DETECTOR
70
64
SYMBOL DEMOD
SYNC. SYMBOL
SYNC. SYMBOL LOCK
68
50
62
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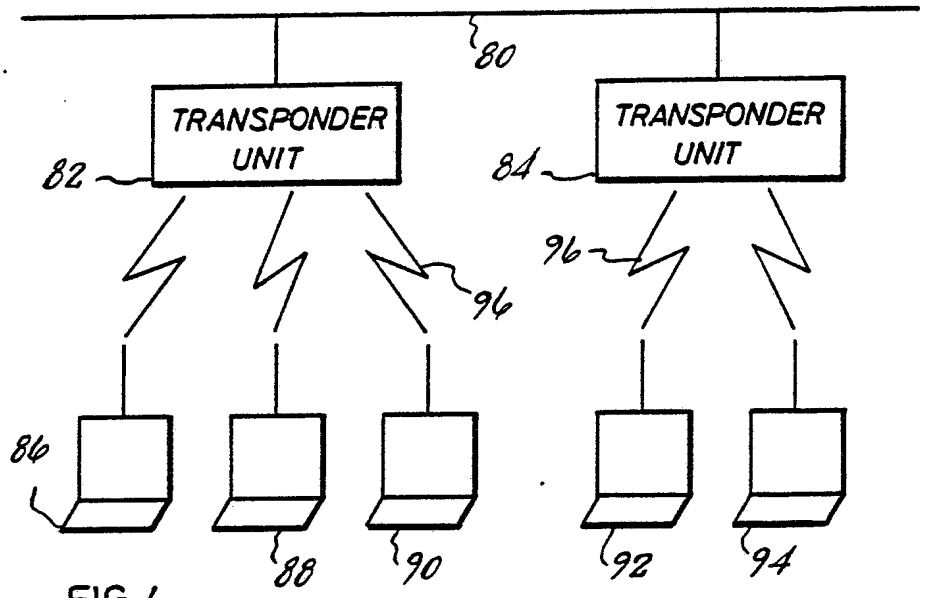
CARRIER LOCK
60
58
PN CODE ACQUISITION AND TRACKING
CODE LOCK
54
54
PREAMP
52

FIG. 2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TRANSPONDER UNIT
82
TRANSPONDER UNIT
84
96
96
86
88
90
92
94

FIG.4

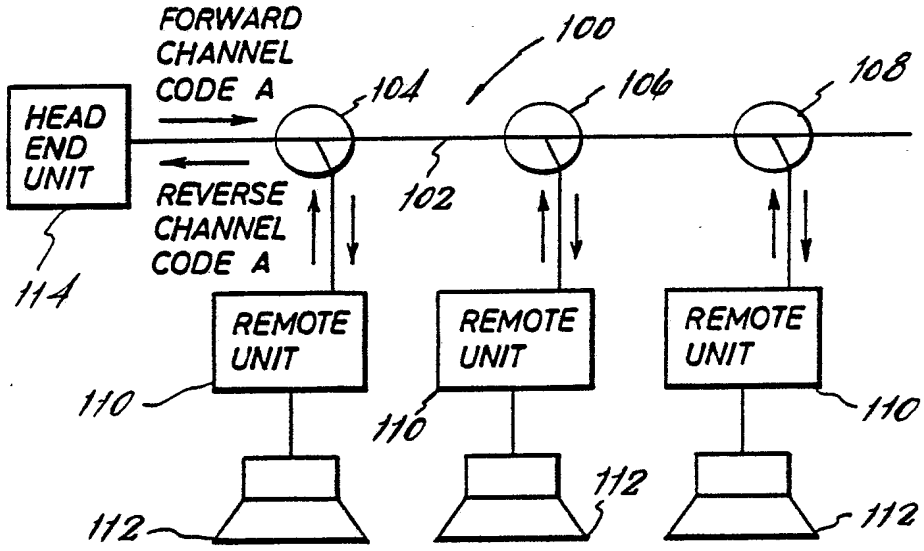
FORWARD CHANNEL CODE A
100
104
106
108
HEAD END UNIT
REVERSE CHANNEL CODE A
102
114
REMOTE UNIT
REMOTE UNIT
REMOTE UNIT
110
110
110
112
112
112

FIG.5

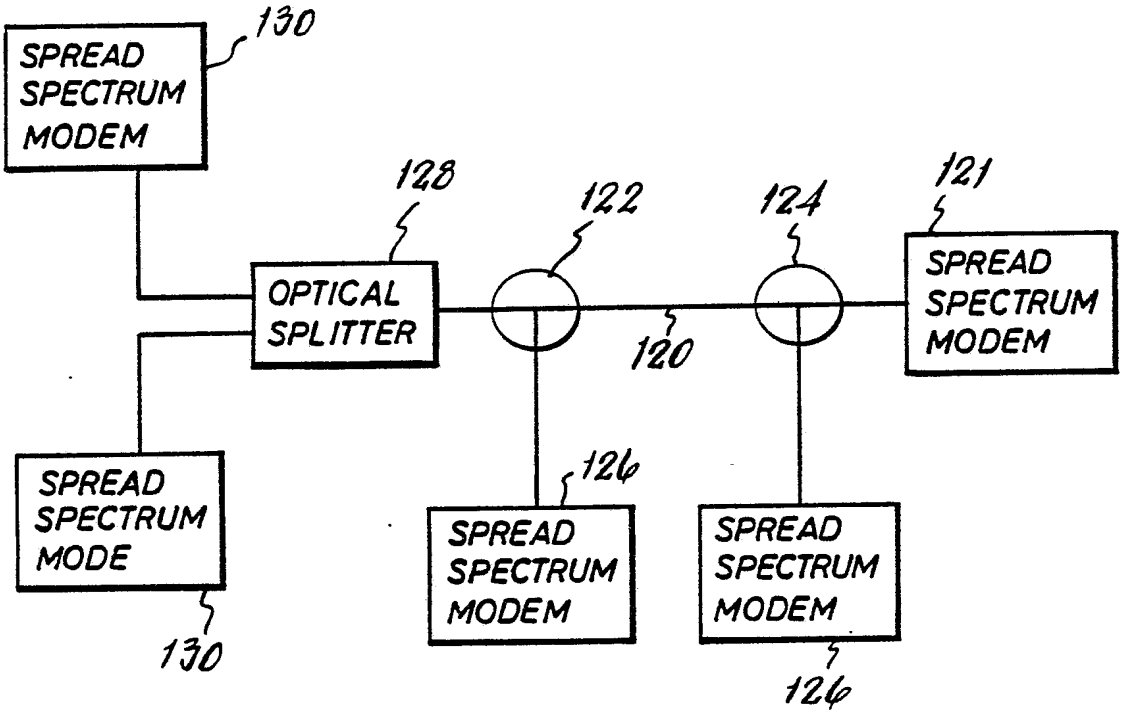
SPREAD SPECTRUM MODEM
130
128
OPTICAL SPLITTER
122
124
121
SPREAD SPECTRUM MODEM
120
SPREAD SPECTRUM MODE
130
126
SPREAD SPECTRUM MODEM
SPREAD SPECTRUM MODEM
126

FIG.6

INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 85/00229

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC[4]: H 04 B 1/66; H 04 J 13/00; H 04 L 11/16

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC[4]	H 04 B H 04 J; H 04 L

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category [10]	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
X	National Telecommunications Conference Washington, 27-29 November 1979, IEEE, (New-York, US) D.C. Coll et al.:"The Use of Spread Spectrum Modulation for the Co-Channel Transmission of Data and Television", pages 15.4.1-15.4.5, see the whole document	1,2,7,8
Y		3-5,9,10
	--	
X	WO, A, 83/02533 (APPLIED SPECTRUM TECHNOLOGIES) 21 July 1983, see page 2, lines 18-36; page 4, lines 27-32	1
	--	
X	Patent Abstracts of Japan, volume 5, nr. 163, pages (E-78) (835), 20 October 1981, see the entire document & JP, A, 5690648 22 July 1981	1
	--	
A	EP, A, 0041253 (NIPPON ELECTRIC) 29 May 1981, see page 20, line 19 - page 21, line 12; page 62, lines 16-21; page 98, line 11 - page 99, line 12	1
Y		3,4

* Special categories of cited documents: [10]

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
29th August 1985	27 SEP 1985
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	G.L.M. Kruydenberg

Form PCT/ISA/210 (second sheet) (January 1985)

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No
X	Compcon Fall 80, 23-25 September 1980, IEEE, (New York, US) P. Freret:"Wireless terminal communications using spread-spectrum Radio", pages 244-248 see paragraph 3	6
Y		5
	--	
A	IEEE Proceedings, volume 128, pt.F, nr. 5, October 1981, (Old Woking, Surrey GB) M.S. Shipton et al.:"Improvements in use of congested spectrum for land mobile radio service by adoption of bandsharing spread-spectrum system wtih TV broadcast channels", pages 245-260 see paragraph 1.1; paragraph 4.2.2; figure 1	1,2,5,7
Y		9
	--	
A	R.C. Dixon:"Spread spectrum systems", 1976 John Willey & Sons, Inc. paragraph 2.1 "Direct sequence (DS) systems", pages 13-26 see pages 14-16	1
Y		10

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON

INTERNATIONAL APPLICATION NO. PCT/GB 85/00229 (SA 9716)

This Annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 09/09/85

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Patent document cited in search report	Publication date	Patent family member(s)		Publication date
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		US-A-	4425642	10/01/84
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		AU-A-	7115681	03/12/81
		US-A-	4392220	05/07/83
		CA-A-	1165476	10/04/84
		AU-B-	537148	07/06/84
		JP-A-	56169951	26/12/81
		JP-A-	56169950	26/12/81
		JP-A-	56169954	26/12/81
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